

Comparative study on qualitative and quantitative analysis of *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) prepared as per The Siddha literature

Research Article

Soruban T^{1*}, Visweswaran S², Meenakumari R³

1. PG Scholar, Department of Gunapadam, National Institute of Siddha, Chennai. India
2. Associate Professor, Department of Gunapadam, National Institute of Siddha, Chennai. India.
3. HOD/Director, National Institute of Siddha, Chennai. India.

Abstract

Therapeutic aspects of Siddha consist of herbal or poly herbal, mineral, metal and animal products which given specific vehicle. Some of the herbal drugs which are used as vehicle may be processed before administration. Among these the *Inji Charu* (Ginger Juice) (*Zinger officinale* Roscoe) is commonly used as *Anupanam* (vehicle). *Inji Charu* has more volatile oils which produce pungent effect, so the process of *Inji surasam* (Ginger Decantent) will reduce the concentration of volatile oils and mitigate the pungent effect. Objective of the study is comparing the chemical constitution of *Inji surasam* and *Inji Charu* was analyzed by HPTLC and FTIR. The study result, Concentration of the major chemical compounds was quality wise same and quantity wise differ in both sample found. Alkyl aryl ether, Anhydride functional group were only present in *Inji charu* and Alkyne Nitro, Sulfonate, Sulfonic Acid, Sulfoxide, Sulfonamide functional group were only present in *Inji Surasam*.

Key Words: *Inji Surasam*, *Inji Charu*, Ginger, HPTLC, FTIR, *Anupanam*.

Introduction

Now a days public are copious concerned in their health and protection from the diseases. They believe in the simple and herbal administration methods of Traditional Medicine. Siddha system is one of the ancient systems among the southern part of India; North and East part of Sri Lanka. The name Siddha medicine owes its origin to medicinal ideas and practices of the Siddhas (1). This system has numerous treatment methods as the form of verses in classical Siddha text books and manuscripts. As reviewing the Siddha literature, all formulations are given specific vehicle in accordance with the disease condition of the body. Some of the herbal drugs which are used as vehicle may be processed before administration. Among these the *Inji Charu* (Ginger Juice) is commonly used as vehicle. *Inji Charu* has more volatile oils which produce pungent effect, so the process of *Inji surasam* (Ginger Decantent) will reduce the concentration of volatile oils and mitigate the pungent effect. But, no any scientific pure with regards to compare the chemical constitution of *Inji Charu* and *Inji Surasam*. So, the study was carried out to compare the *Inji Surasam* and *Inji Charu* through the HPTLC and FTIR analyses.

* Corresponding Author:

Soruban T

PG scholar, Department of Gunapadam,
National Institute of Siddha,
Chennai - 600047 India.
Email Id: sorruthiru@gmail.com

Objective

To evaluate the phytochemical of *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent).

Materials and Methods

Samples preparation methods

Collected Ginger was measured weight and peeled the outer layer of Ginger. It was crushed in stone motor to get juice. The juice was kept for few minutes to settle down. The suspended particles and the supernatant juice was filtered and measured the volume. Then the juice was divided into two equal parts. One half of the juice was stored in air tight glass container labelled as A.

The mud pot was heated in stove until the “sur” sound heard if sprinkled a few drops of water in it and then turn off the stove then second half of the juice was poured into the heated mud pot. After that juice was filtered and measured the volume. Finally, the juice was stored in air tight glass container labelled as sample B. Samples were analyzed by HPTLC and FTIR.

HPTLC instrumentation and condition

HPTLC CAMAG HPTLC Scanner (Model - Scanner III) and Aluminum coated silica gel 60F₂₅₄ TLC plate was used. Toluene: Ethyl acetate (7:3) mixture and Hexane : Ethyl acetate (7:3) mixture used in mobile phase and scanned wavelength were 250nm, 350nm and 450nm.

FTIR instrumentation and condition

The Perkins Elmer Spectrum One Fourier Transform Infrared (FTIR) Spectrometer was used to

Soruban T et.al., Qualitative and quantitative analysis of Inji Charu (Ginger juice) and Inji Surasam (Ginger decantent)

derive the FTIR Spectra of Sample placed in Potassium Bromide (KBr) discs with scan rate of 5 scan per minute at the resolution 4cm-1 in the wave number region 450 - 4000 cm-1. The samples were grinded to fine powder using agate motor and pestle and the mixed

with KBr. They were then pelletized by applying pressure to prepare the specimen (the size of specimen about 13 mm diameter and 0.3 mm in thickness) to recorded the FTIR Spectrum under Standard condition.

Result and Discussions

Figure 01- Qualitative analysis TLC Image of *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent). I - Flavonoid, II - Glycoside, III -Alkaloid, IV - Tannins, V - Saponin, VI - Terpenoids and VII – Proteins

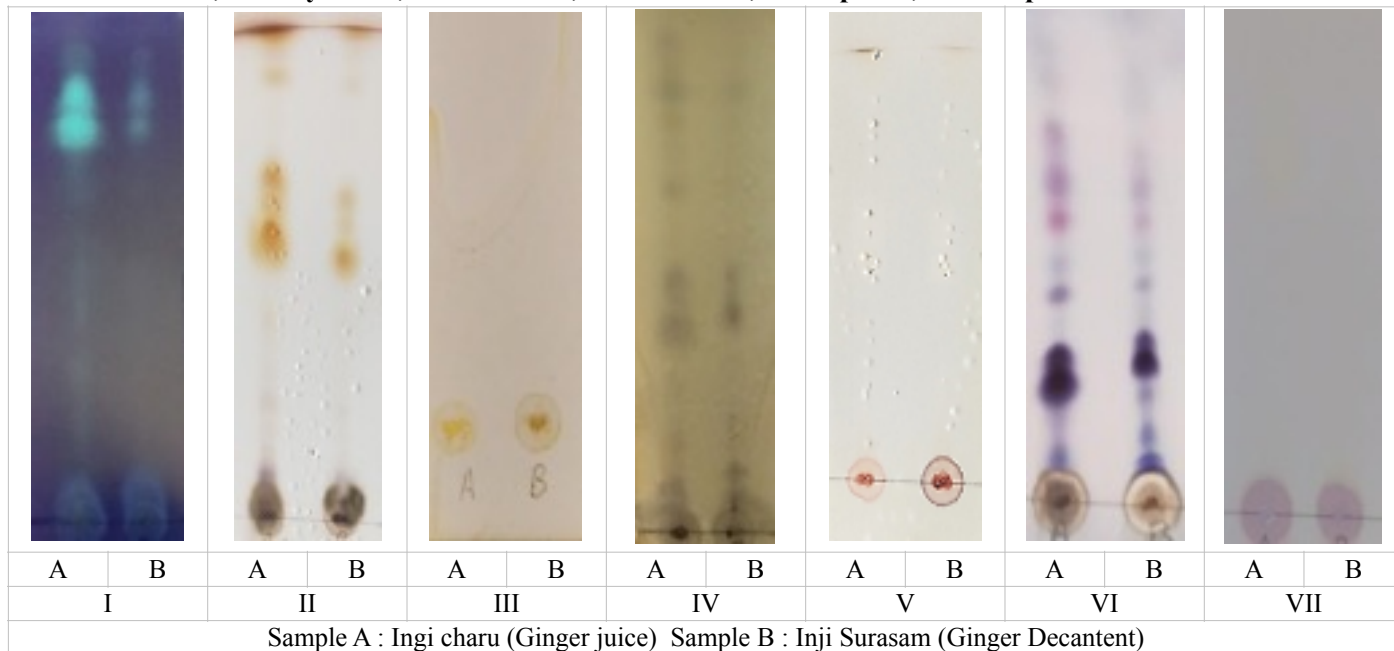


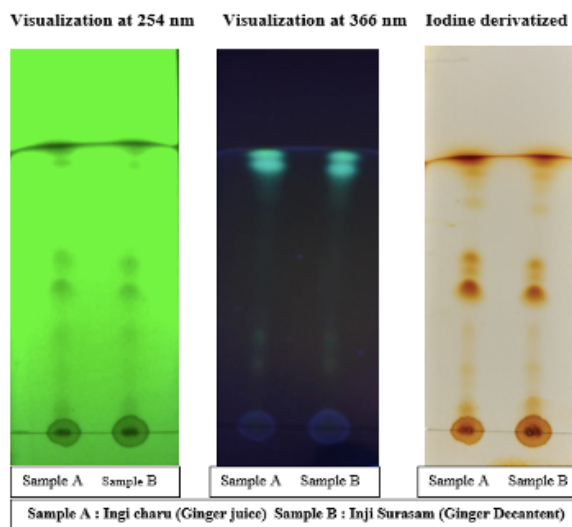
Table 01: Qualitative analysis data interpretation of Sample A : *Inji Charu* (Ginger Juice) and Sample B: *Inji Surasam* (Ginger Decantent)

S. No	Functiona l group	Spray reagents and Derivatization	Observation	Inji Charu (Ginger Juice)	Inji Surasam (Ginger Decantent)
1	Flavonoid	10% AlCl ₃ reagent and heat	Fluorescence	Present	Present
2	Alkaloid	Dragendorff reagent and heat	Orange Spot	Present	Present
3	Glycoside	10% H ₂ SO ₄ and heat	Black Spot	Present	Present
4	Tannins	FeCl ₃ and heat	Blue Sport	Present	Present
5	Saponin	Vanillin - H ₂ SO ₄ reagent and heat	Pink Sport	Present	Present
6	Terpenoids	Anisaldehyde	Purple Sport	Present	Present
7	Proteins	Niinhydrin and heat	Blue Sport	Present	Present

Table 01 and Figure 01 have shown results of phytochemical screening of *Inji charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent). The results obtained revealed the presence Flavonoid, Glycoside, Alkaloid, Tannins, Saponin, Terpenoids and Proteins in

the *Inji charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent). Flavonoid was quantity wise differ in *Inji charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) was found through the TLC Images.

Figure 02 - TLC Image of *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent)



The TLC Image of TLC Silica plates under CAMAG TLC Scanner captured at UV light 254nm, 366nm and Iodine derivatized shown well defined bands were clearly identified the different type of compounds presence in *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) (Figure 02).

Table 02: HPTLC Chromatogram Data interpretation profile of Inji Charu (Ginger Juice) and Inji Surasam (Ginger Decantent) at 250nm

Inji Charu (Ginger Juice)						Inji Surasam (Ginger Decantent)					
Peak No	Max R _f value	Max Height	Max %	Area	Area %	Peak No	Max R _f value	Max Height	Max %	Area	Area %
1	0.03	139.2	15.93	1215.4	5.54	1	0.03	63.3	9.19	403.3	2.42
2	0.06	160.8	18.40	2019.5	9.20	2	0.06	169.2	24.58	2273.5	13.64
3	0.09	30.3	3.47	371.4	1.69	3	0.10	31.4	4.57	468.9	2.81
4	0.16	11.4	1.31	162.3	0.74	4	0.20	26.7	3.88	398.0	2.39
5	0.20	28.9	3.30	654.0	2.98	5	0.30	35.1	5.09	1178.7	7.07
6	0.31	35.0	4.01	1294.8	5.90	6	0.41	200.6	29.15	6403.7	38.43
7	0.43	252.5	28.84	8683.0	39.54	7	0.49	129.4	18.79	4868.9	29.22
8	0.51	161.9	18.58	6498.9	29.60	8	0.66	32.7	4.76	668.5	4.01
9	0.68	54.3	6.22	1058.1	4.82						

As shown in Table 03, presence of 9 compounds were identified having R_f values between 0.03 and 0.68 in *Inji charu* (Ginger Juice) and presence of 8 compounds were identified having R_f values between 0.03 and 0.66 in *Inji Surasam* (Ginger Decantent). The Peak no 7 and 8 indicated the major compounds having area percentage and R_f value as 39.54% at 0.43 and 29.6% at 0.51 in *Inji charu* (Ginger Juice). The Peak no 6 and 7 indicated the major compounds having area percentage and R_f value as 38.43% at 0.41 and 29.22% at 0.49 in *Inji Surasam* (Ginger Decantent).

According to the Table 05, presence of 9 compounds were identified between R_f values of 0.03 and 0.66 in *Inji charu* (Ginger Juice) and 7 compounds were identified between R_f values of 0.06 and 0.66 in *Inji Surasam* (Ginger Decantent). The Peak no 6 indicated the major compound having area percentage and R_f value as 25.49% at 0.43 in *Inji charu* (Ginger Juice). The Peak no 6 indicated the major compound having area percentage and R_f value as 32.47% at 0.46 in *Inji Surasam* (Ginger Decantent).

Table 03: HPTLC Chromatogram Data interpretation profile of Inji Charu (Ginger Juice) and Inji Surasam (Ginger Decantent) at 350nm

Inji Charu (Ginger Juice)						Inji Surasam (Ginger Decantent)					
Peak No	Max R _f value	Max Height	Max %	Area	Area %	Peak No	Max R _f value	Max Height	Max %	Area	Area %
1	0.03	164.0	33.78	1043.3	11.53	1	0.06	68.6	25.62	718.4	12.70
2	0.06	65.3	13.45	761.4	8.42	2	0.20	30.4	11.32	685.1	12.11
3	0.20	43.1	7.03	845.0	9.34	3	0.27	26.8	9.96	727.9	12.87
4	0.27	36.7	7.56	1104.6	12.21	4	0.31	25.4	9.47	546.5	9.66
5	0.32	29.6	6.09	681.1	7.53	5	0.40	49.7	18.49	858.8	15.18
6	0.43	54.7	11.28	2305.9	25.49	6	0.46	51.8	18.28	1836.8	32.47
7	0.48	48.3	9.95	1101.5	12.18	7	0.66	15.8	5.87	283.7	5.01
8	0.51	34.2	7.04	837.5	9.26						
9	0.68	18.6	3.83	365.9	4.05						

Figure 03 - Chromatogram of Sample A : Inji Charu (Ginger Juice) and Sample B: Inji Surasam (Ginger Decantent) at 250 nm

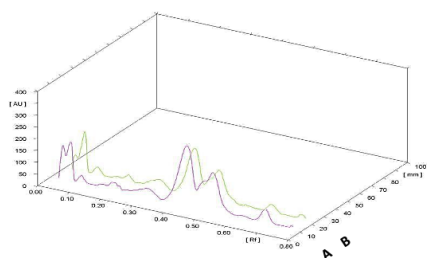


Figure 04 - Chromatogram of Sample A : Inji Charu (Ginger Juice) and Sample B: Inji Surasam (Ginger Decantent) at 350 nm.

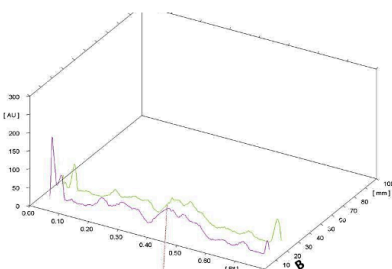


Figure 05 - Chromatogram of Sample A : Inji Charu (Ginger Juice) and Sample B: Inji Surasam (Ginger Decantent) at 450 nm

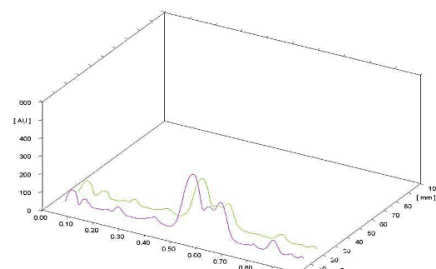


Table 04: HPTLC Chromatogram Data interpretation profile of *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) at 450nm

Inji Charu (Ginger Juice)						Inji Surasam (Ginger Decantent)					
Peak No	Max R _f value	Max Height	Max %	Area	Area %	Peak No	Max R _f value	Max Height	Max %	Area	Area %
1	0.06	71.5	7.26	1221.9	4.72	1	0.06	69.0	9.89	1409.1	8.05
2	0.11	38.4	3.90	558.3	2.16	2	0.13	36.7	5.27	673.9	3.85
3	0.20	11.0	1.11	142.0	0.55	3	0.21	11.2	1.60	136.2	0.78
4	0.24	38.2	3.88	667.1	2.58	4	0.25	31.2	4.48	496.8	2.84
5	0.38	32.5	3.30	802.3	3.10	5	0.38	23.4	3.36	576.5	3.29
6	0.53	321.3	32.61	12369.0	47.78	6	0.51	237.2	34.01	8563.8	48.91
7	0.59	162.8	16.52	3079.3	11.89	7	0.57	108.7	15.59	1581.1	9.03
8	0.64	201.9	20.49	5418.3	20.93	8	0.61	132.1	18.93	3236.2	18.48
9	0.77	18.7	1.90	200.0	0.77	9	0.82	35.3	5.06	706.7	4.04
10	0.84	64.5	6.54	1236.5	4.78	10	0.95	12.5	1.80	128.6	0.73
11	0.91	11.6	1.17	121.5	0.47						
12	0.95	12.9	1.31	72.0	0.28						

Table 04, presence of 12 compounds were identified between R_f values of 0.06 and 0.95 in *Inji charu* (Ginger Juice) and 10 compounds were identified between R_f values of 0.06 and 0.95 in *Inji Surasam* (Ginger Decantent). The Peak no 6 indicated the major compound having area percentage and R_f value as 47.78% at 0.53 in *Inji charu* (Ginger Juice). The Peak no 6 was indicated the major compound having area percentage and R_f value as 48.91% at 0.51 in *Inji Surasam* (Ginger Decantent).

Histogram under the CAMAG HPTLC scanner captured at 450 nm light results were proved 12 and 10 compounds which were presence in *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) shown as Figure 06. Here is, when the red line cut the red squares that are proved as presence of same type of compound in both samples. The same type of compounds was presence in *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) was 10 in total number.

Figure 06 - Histogram of Sample A : *Inji Charu* (Ginger Juice) and Sample B: *Inji Surasam* (Ginger Decantent) at 450 nm

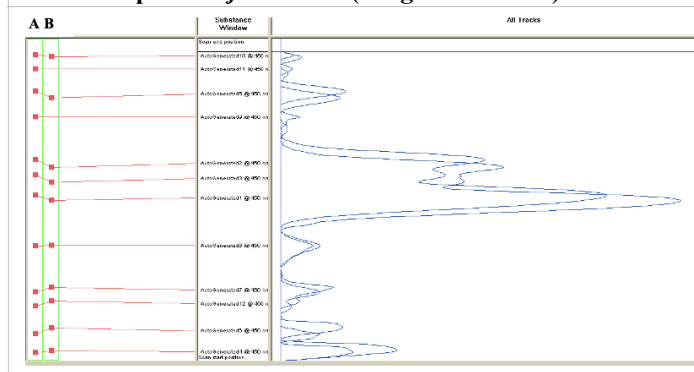
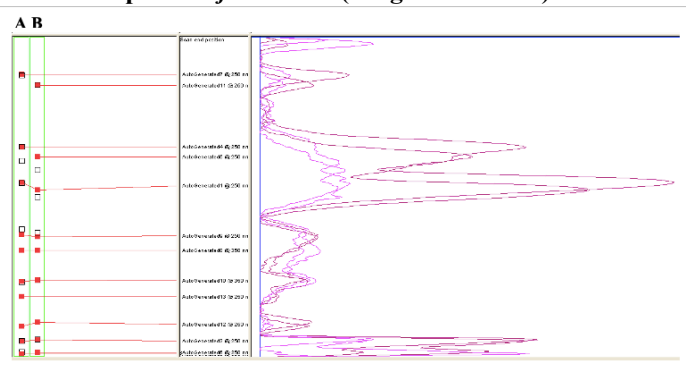


Figure 07 - Histogram of Sample A : *Inji Charu* (Ginger Juice) and Sample B: *Inji Surasam* (Ginger Decantent) at 250 nm



Histogram under the CAMAG HPTLC scanner captured at 250 nm light results were proved 10 and 9 compounds which were presence in *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) shown as Figure 6. The same type of compounds was presence in *Inji Charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) was 07 in total number.

Table 05: The functional compounds of *Inji Charu* (Ginger Juice) analyzed by using FTIR.

Wave length (cm ⁻¹)	Appearance	Vibration type	Functional compound
3404	Strong	O - H Stretching	Alcohol
2924	Strong	CH ₂ (Asymmetrical stretch)	Alkane
2853	Strong	CH ₂ (Symmetrical stretch)	Alkane
2059	Weak	-	-
1647	Strong	C=C stretching	Alkene
1470	Strong	C- H Scissoring	Alkyne
1249	Strong	C- O Stretching	Alkyl aryl ether
1153	Strong	C- OH Stretching	Tertiary alcohol
1041	Strong	CO-O-CO Stretch	Anhydride
860	Medium	C- H Bending	Aromatic
568	Medium	C- Br	Alkyl halide

Figure 08 - Image of the FTIR spectrum of Inji Charu (Ginger Juice)

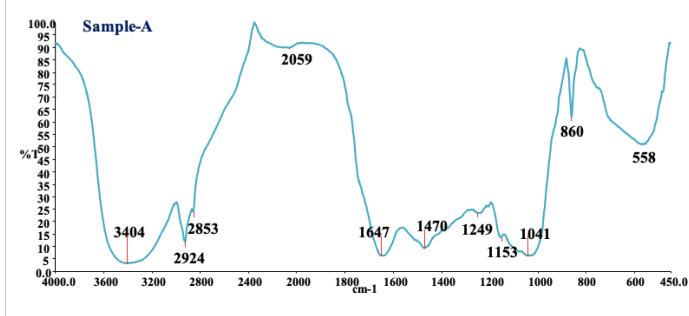
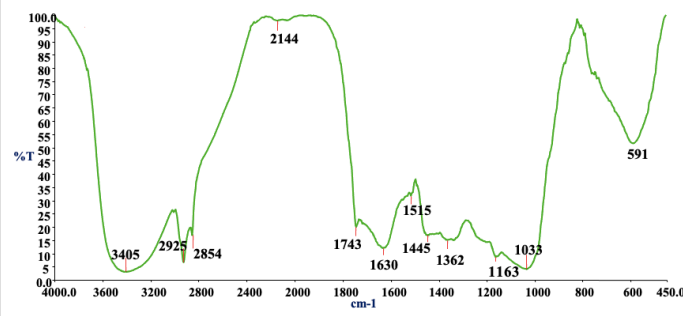


Figure 09- Image of the FTIR spectrum of Inji Surasam (Ginger Decantent)



In this study the FTIR spectrum was used to identify the functional groups of the active components present in sample based on the peak's values in the region of IR radiation. When the sample was passed into the FTIR, the functional groups of the components were separated based on its peak's ratio. The infra red spectrum of Inji Charu (Ginger Juice) as shown in Figure 08 was in the wave length range of 558 cm^{-1} to 3404 cm^{-1} and there 11 type of vibrations found and expected functional compounds were identified (Table 05). The results of FTIR spectroscopy confirmed the presence of various chemical constituents such as Alcohol, Alkanes, Alkenes, Alkyne, Alkyl aryl ether, Tertiary alcohol and Anhydride which were identified by following strong characteristic absorption bands were exhibited at 3404 cm^{-1} , 2924 cm^{-1} , 2853 cm^{-1} , 1647 cm^{-1} , 1470 cm^{-1} , 1249 cm^{-1} , 1153 cm^{-1} and 1041 cm^{-1} . The medium instance peaks were identified at 860 cm^{-1} and 568 cm^{-1} which were assigned the Aromatic and Alkyl halide groups. The weak characteristic absorption bands were exhibited at 2059 cm^{-1} was not identified.

The infra red spectrum of Inji Surasam (Ginger Decantent) as shown in Figure 09 was in the wave length range of 591 cm^{-1} to 3405 cm^{-1} and there 12 type of vibrations found and expected functional compounds were identified (Table 06). The results of FTIR spectroscopy confirmed the presence of various chemical constituents such as Alcohol, Alkanes, Ester, Alkene, Nitro, Tertiary alcohol, Sulfonate, Sulfonamide, Sulfonic Acid and Sulfoxide which were identified by following strong characteristic absorption bands were exhibited at 3405 cm^{-1} , 2925 cm^{-1} , 2854 cm^{-1} , 1743 cm^{-1} , 1630 cm^{-1} , 1515 cm^{-1} , 1445 cm^{-1} , 1362 cm^{-1} , 1163 cm^{-1} and 1033 cm^{-1} . The medium instance peaks were identified at 591 cm^{-1} which was assigned the Alkyl halide group. The weak characteristic absorption bands were exhibited at 2144 cm^{-1} for Alkyne compound.

Table 06: The functional compounds of Inji Surasam (Ginger Decantent) analyzed by using FTIR.

Wave length (cm^{-1})	Appearance	Vibration type	Functional compound
3405	Strong	O - H Stretching	Alcohol
2925	Strong	CH ₂ (Asymmetrical stretch)	Alkane
2854	Strong	CH ₂ (Symmetrical stretch)	Alkane
2144	Weak	C≡C stretching	Alkyne
1743	Strong	C=O Stretching	Ester
1630	Strong	C=C stretching	Alkene
1515	Strong	NO ₂ Stretching	Nitro
1445	Strong	C - O Stretch	Tertiary alcohol
1362	Strong	S=O stretching	Sulfonate
1163	Strong	C - O Stretching	Sulfonic Acid
1033	Strong	S=O stretching	Sulfoxide
591	Medium	C - Br	Alkyl halide

According to the Table 06, O - H Stretching (Alcohol), CH₂ Asymmetrical stretch (Alkane), CH₂ Symmetrical stretch (Alkane), C=C stretching (Alkene), and C -Br (Alkyl halide) vibrations were identified the Inji Charu (Ginger Juice) and Inji Surasam (Ginger Decantent). C - H Bending (Aromatic), C - H Scissoring (Alkyne), C - O Stretching (Alkyl aryl ether) and CO-OCO Stretch (Anhydride) vibrations were only identified the Inji Charu (Ginger Juice). C≡C stretching (Alkyne), C=O Stretching (Ester), NO₂ Stretching (Nitro), S=O stretching (Sulfonate), S=O stretching (Sulfonic Acid), S=O stretching (Sulfoxide) and S=O stretching (Sulfonamide) vibrations were only identified the Inji Surasam (Ginger Decantent).

Table 07: Compare the functional compounds of Inji Charu (Ginger Juice) and Inji Surasam (Ginger Decantent) using FTIR analysis

No	Vibration type	Functional compound	Inji Charu (Ginger Juice)	Inji Surasam (Ginger Decantent)
1	O - H Stretching	Alcohol	Present	Present
2	CH ₂ (Asymmetrical stretch)	Alkane	Present	Present
3	CH ₂ (Symmetrical stretch)	Alkane	Present	Present
4	C=C stretching	Alkene	Present	Present

Soruban T et al., Qualitative and quantitative analysis of Inji Charu (Ginger juice) and Inji Surasam (Ginger decantent)

5	C=C stretching	Alkyne	Absent	Present
6	C- H Bending	Aromatic	Present	Absent
7	C- H Scissoring	Alkyne	Present	Absent
8	C=O Stretching	Ester	Absent	Present
9	C- O Stretching	Alkyl aryl ether	Present	Absent
10	C- OH Stretching	Tertiary alcohol	Present	Absent
11	CO-O-CO Stretch	Anhydride	Present	Absent
12	NO ₂ Stretching	Nitro	Absent	Present
13	S=O stretching	Sulfonate	Absent	Present
14	S=O stretching	Sulfonic Acid	Absent	Present
15	S=O stretching	Sulfoxide	Absent	Present
16	S=O stretching	Sulfonamide	Absent	Present
17	C -Br	Alkyl halide	Present	Present

Conclusion

Concentration of the major chemical compounds was quality wise same and quantity wise differ in *Inji charu* (Ginger Juice) and *Inji Surasam* (Ginger Decantent) were found through the HPTLC analysis.

Alkyl aryl ether, Anhydride functional group were only present in *Inji charu* (Ginger Juice) and Alkyne Nitro, Sulfonate, Sulfonic Acid, Sulfoxide, Sulfonamide functional group were only present in *Inji Surasam* (Ginger Decantent) through the FTIR analysis.

Acknowledgement

The authors are thankful to the Director, National Institute of Siddha and Vice-Chancellor, Tamil Nadu Dr. M.G.R. Medical University, Chennai for providing necessary facilities to carry out this work.

References

- Subbarayappa BV. Siddha medicine: an overview. *Lancet*. 1997 Dec 20-27; 350(9094):1841-4. doi: 10.1016/s0140-6736(97)04223-2. PMID: 9428267.
- Sambasivampillai T. V, Tamil - English Dictionary of Medicine, Chemistry, Botany and Allied Science, The Research Institute of Siddhar's Sciences, 1931; Vol. 1; page 524, 528 - 531.
- Pitchiah kumar M., Senthilvel G. and Jeyavenkatesh J., *Fundamentals of Siddha Internal Medicine*, Shanlax Publications, 2018; page 43 - 50..
- Thiagarajan. R., *Siddha Materia Medica (Mineral and Animal Section)*, Translation & Publications wing, Department of Indian Medicine and Homoeopathy, 2008; page - 58
- Imad A. Abu Yousef et al., Simplified HPLC method for identification of Gingerol and Mangiferin in herbal extracts, *European Journal of Scientific Research*, 2011; Vol.66 No.1; page 21-28.
- Srinivasan. S, Anti-Inflammatory, Analgesic and Anti-Pyretic Activity of Chukku Chooranam & Anti-Ulcer Activity of Annabedhi Chenduram (Dissertation Subject), Government Siddha Medical College, Tirunelveli – 627002, March 2009; page 6.
- Kirtikar K R, and Basu B D, *Indian Medicinal plants*, Periodical Experts Book Agency, second edition 1993; Vol IV; page 2435 – 2438.
- The Siddha Pharmacopoeia of India, The Controller of publication, Civil lines, Delhi 110054, 1st Edition 2011; Part I; Vol I; page 69 – 71.
- Neeraj Tandon and Madhu Sharma (editors), *Quality standards of Indian medicinal plants*, Medicinal Plants unit, Indian council of Medical Research, New Delhi, 2010; Vol 8; page 347 - 354.
- Jayaweera D. M.A., *Medicinal Plants (Indigenous and Exotic) used in Ceylon*, The national science foundation, Sri lanka, 2006; Part V; page 217.
- Wealth of India, National Institute of Science Communication and Information Resource, 2009; Vol 3 (Pi – Z); page 273.
- Indian Herbal Pharmacopoeia, Indian Drug Manufacturers' Association, Revised new edition, 2002; page 479 - 488.
- Murugesu Muthaliyar K S, *Siddha Materia Medica (Medicinal Plant Division)*, Indian medicine and Department of Homoeopathy, Chennai 106, 8th Edition, 2004; p98 - 101.
- Mohd Mujeeb et al., Determination Of 10-Gingerol In Indian Ginger by Validated HPTLC Method Of Samples Collected Across Subcontinent Of India, *International Journal of Pharmacy and Pharmaceutical Sciences*, 2016; Vol 8(12); page 190 – 193.
- Osabor V. N. et al., Phytochemical Screening and Quantitative Evaluation of Nutritional Values of *Zingiber officinale* (Ginger), *American Chemical Science Journal*, 2015; Vol 8(4); page 1- 6.
- Jacob Olalekan Arawande et al., Extractive Value and Phytochemical Screening of Ginger (*zingiber officinale*) and Turmeric (*curcuma longa*) Using Different Solvents, *International Journal of Traditional and Natural Medicines*, 2018; vol 8(1); page 13-22.
- Samiuela Lee et al., Liquid Chromatographic Determination of 6-, 8-, 10 Gingerol, and 6-Shogaol in Ginger (*Zingiber officinale*) as the Raw Herb and Dried Aqueous Extract, *Journal Of AOAC International*, 2007; Vol 90(5); page 1219 -1226.
- Gelila Asamenew et al., Characterization of phenolic compounds from normal ginger (*Zingiber officinale* Rosc.) and black ginger (*Kaempferia parviflora* Wall.) using UPLC–DAD–QToF–MS, *European Food Research and Technology*, 2019; 245; page 653 – 665.

19. Khushbu Sharma et al., studied Chemical constituents of *Zingiber officinale* rhizome, Journal of Medicinal Plants Studies 2018; Vol 6(1); page 146-149.
20. El-Ghorab et al., A Comparative Study on Chemical Composition and Antioxidant Activity of Ginger (*Zingiber officinale*) and Cumin (*Cuminum cyminum*), Journal of Agriculture and Food Chemistry, 2010; Vol 58(14); page 8231- 8237.
21. Niraimathi K.L. et al., Spectroscopic and chromatographic technique in the analysis of herbs and herbal formulations, Modern Instrumentation Techniques, Centre for Advanced Research in Indian System of Medicine (CARISM), page 53 – 71.
